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From:	**Rachel V. Leiterman**
Serial No.:	**10/033,349**
Docket:	**M-11972 US** **(LUM- M-11972 US)**
Re:	**Appeal Brief**
Pages:	**39(including cover sheet)**

Message:

Re: Applicant(s): Yu-Chen Shen; Mira S. Misra
Assignee: Lumileds Lighting U.S. LLC
Title: Indium Gallium Nitride Separate Confinement Heterostructure Light Emitting Devices
Serial No.: 10/033,349
Examiner: Douglas A. Wille Filed: November 2, 2001
Docket No.: M-11972 US Group Art Unit: 2814

Dear Sir:

Transmitted herewith are the following documents in the above-identified application:

(1) Transmittal Letter (1 page in duplicate);
(2) Appeal Brief (12 pages in triplicate).

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Brian D. Ogonowsky
Carmen C. Cook
David C. Hsia
Rachel V. Leiterman

May 17, 2004

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Re: Applicant(s):	Yu-Chen Shen; Mira S. Misra		
Assignee:	Lumileds Lighting U.S., LLC		
Title:	Indium Gallium Nitride Separate Confinement Heterostructure Light Emitting Devices		
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☐ No additional fee is required.
☒ The fee has been calculated as shown below:

☒	**Fee to file Appeal Brief**	$	330.00
☒	**Fee for Extension of Time (3 months)**	$	950.00
☒	Conditional Petition for Extension of Time: If an extension of time is required for timely filing of the enclosed document(s) after all papers filed with this transmittal have been considered, an extension of time is hereby requested.		
☒	Also, charge any additional fees required and credit any overpayment to our Deposit Account No. 502226.		
	Total:	$	1,280.00

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I hereby certify that this paper is being facsimile transmitted to the U.S. Patent and Trademark Office on the date shown below.

R Leiterman 5/17/04
Signature Date

Respectfully submitted,

Rachel V. Leiterman
Attorney for Applicant(s)
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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San Jose, California
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APPEAL BRIEF UNDER 37 CFR § 1.191

Dear Sir:

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I. REAL PARTY IN INTEREST

The real partying interest is the assignee, Lumileds Lighting U.S. LLC, as named in the caption above.

II. RELATED APPEALS AND INTERFERENCES

Based on information and belief, there are no appeals or interferences that could directly affect or be directly affected by or have a bearing on the decision by the Board of Patent Appeals in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-17 and 19-28 are pending in the present application, all of which stand rejected. Claim 18 is canceled. Claims 1-17 and 19-28 are hereby appealed.

IV. STATUS OF AMENDMENTS

The Examiner issued the final action on July 22, 2003. Applicants did not file an after final amendment.

V. SUMMARY OF THE INVENTION

Semiconductor light-emitting devices (LEDs) are among the most efficient light sources currently available. Materials systems currently of interest in the manufacture of high-brightness LEDs capable of operation across the visible spectrum include Group III-V semiconductors, particularly binary, ternary, and quaternary alloys of gallium, aluminum, indium, and nitrogen, also referred to as III-nitride materials. Typically, III-nitride light emitting devices are fabricated by epitaxially growing a stack of semiconductor layers of different compositions and dopant concentrations on a sapphire, silicon carbide, or III-nitride substrate by metal-organic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE), or other epitaxial techniques. The stack often includes one or more n-type layers doped with, for example, Si, formed over the substrate, a light emitting or active region

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formed over the n-type layer or layers, and one or more p-type layers doped with, for example, Mg, formed over the active region. (Specification, paragraph [0001])

The active region is often a single quantum well layer, or multiple quantum well layers separated by and sandwiched between layers of semiconductor materials with larger bandgap energies than the quantum well layers. The larger bandgap energy layers that separate the quantum well layers are often referred to as barrier layers. The larger bandgap energy layers between which the active region is located are often referred to as cladding or confinement layers. Other layers may be located between the confinement layers and the active region. The barrier and confinement layers provide barriers to the diffusion of charge carriers away from the active region. (Specification, paragraph [0002])

One aspect of the invention provides a semiconductor light emitting device. (Claim 1, Figs. 3 and 4, Specification paragraphs [0015] through [0027]) The device includes a substrate; a first conductivity type layer overlying the substrate; and an $In_xGa_{1-x}N$ lower confinement layer overlying the first conductivity type layer, wherein $0 \leq x \leq 0.15$; and a spacer layer overlying the lower confinement layer. The device also includes an active region overlying the spacer layer, the active region including a quantum well layer and a barrier layer comprising indium. Over the active region are a cap layer overlying the active region; an $In_xGa_{1-x}N$ upper confinement layer overlying and adjacent to the cap layer, wherein $0 \leq x \leq 0.15$; and a second conductivity type layer overlying the upper confinement layer. The spacer layer and the cap layer have larger band gaps than the quantum well layer. The upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer. One of the spacer layer and the cap layer comprises indium.

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VI. ISSUES

Whether claims 1-17 and 19-28 are unpatentable under 35 U.S.C. § 103(a) as being obvious over Sasanuma et al. JP 11243251 in view of Sverdlov, U.S. Patent No. 6,455,337.

VII. GROUPING OF THE CLAIMS

Claims 1-17 and 19-28 stand or fall together.

VIII. ARGUMENTS

Claims 1, 6, 7, 9, 11, 13, 14, 16, 17, 20, 22 and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sasanuma et al. JP 11243251 (hereinafter "Sasanuma") in view of Sverdlov, U.S. Patent No. 6,455,337.

Claim 1 recites:

> A light emitting device comprising:
> a substrate;
> a first conductivity type layer overlying the substrate;
> a lower confinement layer overlying the first conductivity type layer, the lower confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$;
> a spacer layer overlying the lower confinement layer;
> an active region overlying the spacer layer, the active region comprising:
> a quantum well layer; and
> a barrier layer comprising indium;
> a cap layer overlying the active region;
> an upper confinement layer overlying and adjacent to the cap layer, the upper confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$; and
> a second conductivity type layer overlying the upper confinement layer;
> wherein:
> the spacer layer and the cap layer have larger band gaps than the quantum well layer;
> the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer; and
> one of the spacer layer and the cap layer comprises indium.

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The Examiner cites Figs. 5, 6, and 7 of Sasanuma as teaching "a laser diode with a substrate 1, a first type layer 3, an InGaN layer 14, an AlGaN layer 15, an[] InGaN MQW

layer 16, an AlGaN layer 17, an InGaN layer 18, a GaN layer 8 and a second [p-]type layer 9." See July 22, 2003 Final Office Action, page 2. In the response to arguments section on page 6 of the same office action, the Examiner states "The layers of Sas[a]numa et al. were recited in the order shown in the claims and layer 15 and 17 correspond to the spacer and cap layers of the claims. Thus all the claimed layers are shown."

The Examiner has not specified which of Sasanuma's layers correspond to which of the layers in claim 1 other than that Sasanuma's layers 15 and 17 correspond to the spacer layer and the cap layer. Applicants assume that the Examiner intends for the layers of Sasanuma to correspond to claim 1 as follows:

Claim 1	Sasanuma
Substrate	Layer 1
First conductivity type layer	Layer 3
Lower confinement layer	Layer 14
Spacer layer	Layer 15
Active region	Layer 16
Cap layer	Layer 17
Upper confinement layer	Layer 18
Second conductivity type layer	Layer 8 or 9

Sverdlov is cited as teaching that Sasanuma's AlGaN layers 15 and 17 may be replaced with GaN layers. The Examiner states: "Sasanuma et al. show layers 15 and 17 as AlGaN and Sverdlov shows that AlGaN can be avoided by using GaN instead (see abstract) to improve the device as shown in the abstract. It would have been obvious to use the GaN as shown by Sverdlov to gain the advantage shown." See July 22, 2003 Final Office Action, page 2.

Applicants respectfully submit that the Examiner's combination of Sverdlov and Sasanuma does not teach that "the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer" as recited in claim 1. As recited above, the Examiner cites Sasanuma's AlGaN layers 15 and 17 of Fig. 6 as being the spacer and cap layer. Fig. 5 of Sasanuma clearly shows that AlGaN layers 15 and 17 have

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larger band gaps than InGaN layers 14 and 18, which Applicants assume the Examiner intends to be the upper and lower confinement layers of claim 1.

In addition, even if Sverdlov's GaN layers were substituted for Sasanuma's AlGaN layers 15 and 17 in Sasanuma's device as proposed by the Examiner, layers 15 and 17 *still* would not meet claim 1's requirement that "the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer", since InGaN layers 14 and 18, which Applicants assume the Examiner intends to be the upper and lower confinement layers of claim 1, contain indium. It is well known in the art that InGaN has a smaller band gap than GaN, and the band gap of InGaN decreases as the amount of indium increases.

Further, the Examiner's combination of Sasanuma and Sverdlov does not teach "one of the spacer layer and the cap layer comprises indium" as recited in claim 1. The layers of Sasanuma cited by the Examiner as the spacer layer and cap layer are AlGaN, and the Examiner cites Sverdlov as teaching that GaN can be substituted for AlGaN. If the spacer layer and cap layer are AlGaN or GaN, neither the spacer layer nor the cap layer comprises indium as recited in claim 1.

Since the Examiner's combination of Sasanuma and Sverdlov does not teach all the elements of claim 1, Applicants respectfully request that the Examiner's rejection is unfounded. Claims 2-17 and 19-28 depend from claim 1 and are therefore not obvious over Sasanuma and Sverdlov for at least the same reasons as claim 1.

Claims 2-5, 8, 10, 12, 15, 19, 21, and 24-28 are rejected over Sasanuma and Sverdlov in view of various other references. Each of the other references is directed to a limitation present in the dependent claims, and as such these references add nothing to the deficiencies of Sasanuma and Sverdlov with respect to claim 1, argued above.

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IX. CONCLUSION

For the above reasons, Applicants respectfully submit that the rejection of pending claims 1-17 and 19-28 is unfounded. Accordingly, Applicants request that the rejection be reversed.

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Rachel V. Leiterman
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APPENDIX

1. A light emitting device comprising:

a substrate;

a first conductivity type layer overlying the substrate;

a lower confinement layer overlying the first conductivity type layer, the lower confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$;

a spacer layer overlying the lower confinement layer;

an active region overlying the spacer layer, the active region comprising:

a quantum well layer; and

a barrier layer comprising indium;

a cap layer overlying the active region;

an upper confinement layer overlying and adjacent to the cap layer, the upper confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$; and

a second conductivity type layer overlying the upper confinement layer;

wherein:

the spacer layer and the cap layer have larger band gaps than the quantum well layer;

the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer; and

one of the spacer layer and the cap layer comprises indium.

2. The light emitting device of Claim 1 wherein the spacer layer comprises indium; and

the barrier layer comprises InGaN with an indium composition between about 1% and about 15%.

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3. The light emitting device of Claim 2 wherein the barrier layer is InGaN having an indium composition between about 1% and about 5%.

4. The light emitting device of Claim 2 wherein the barrier layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{19} cm^{-3}.

5. The light emitting device of Claim 2 wherein:

the barrier layer has a thickness between about 20 angstroms and about 250 angstroms;

the quantum well layer has an indium composition between about 4% and about 25%; and

the quantum well layer has a thickness between about 10 angstroms and about 60 angstroms.

6. The light emitting device of Claim 1 wherein the barrier layer, the spacer layer, and the cap layer each have an indium composition less than an indium composition of the quantum well layer.

7. The light emitting device of Claim 1 wherein the lower confinement layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.02$.

8. The light emitting device of Claim 1 wherein the lower confinement layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{22} cm^{-3}.

9. The light emitting device of Claim 1 wherein the lower confinement layer has a thickness between about 50 and about 20,000 angstroms.

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10. The light emitting device of Claim 2 wherein:

the lower confinement layer has a first indium composition;

the spacer layer has a second indium composition;

the quantum well layer has a third indium composition;

the third indium composition is greater than the second indium composition; and

the second indium composition is greater than or equal to the first indium composition.

11. The light emitting device of Claim 1 wherein the upper confinement layer comprises $In_xGa_{1-x}N$, wherein $0 \le x \le 0.02$.

12. The light emitting device of Claim 1 wherein the upper confinement layer is doped with a dopant of second conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{22} cm^{-3}.

13. The light emitting device of Claim 12 wherein the dopant comprises Mg.

14. The light emitting device of Claim 1 wherein the upper confinement layer has a thickness between about 50 and about 20,000 angstroms.

15. The light emitting device of Claim 2 wherein:

the upper confinement layer has a first indium composition;

the cap layer has a second indium composition;

the quantum well layer has a third indium composition;

the third indium composition is greater than the second indium composition; and

the second indium composition is greater than or equal to the first indium composition.

16. The light emitting device of Claim 1 wherein the cap layer comprises $In_xGa_{1-x}N$, wherein $0 \le x \le 0.15$.

17. The light emitting device of Claim 1 wherein the spacer layer comprises $In_xGa_{1-x}N$, wherein $0 \le x \le 0.15$.

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19. The light emitting device of Claim 1 wherein at least one of the cap layer, the upper confinement layer, the lower confinement layer, and the spacer layer comprises a graded composition of indium.

20. The light emitting device of Claim 1 wherein the cap layer is doped with a dopant of second conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{21} cm^{-3}.

21. The light emitting device of Claim 1 wherein the spacer layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{21} cm^{-3}.

22. The light emitting device of Claim 1 wherein the first conductivity type layer and the second conductivity type layer have larger band gaps than the lower confinement layer and the upper confinement layer.

23. The light emitting device of Claim 1 wherein the spacer layer and the cap layer have larger band gaps than the barrier layer.

24. The light emitting device of Claim 1 wherein the spacer layer comprises a composition graded from a first composition in a first region of the spacer layer to a second composition in a second region of the spacer layer, wherein:

the first region is closer to the lower confinement layer than the active region;

the second region is closer to the active region than the lower confinement layer; and

the second composition comprises a higher indium composition than the first composition.

25. The light emitting device of Claim 1 wherein the cap layer comprises a composition graded from a first composition in a first region of the cap layer to a second composition in a second region of the cap layer, wherein:

the first region is closer to the upper confinement layer than the active region;

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the second region is closer to the active region than the upper confinement layer; and

the second composition comprises a higher indium composition than the first composition.

26. The light emitting device of Claim 1 wherein the upper confinement layer comprises a composition graded from a first composition in a first region of the upper confinement layer to a second composition in a second region of the upper layer, wherein:

the first region is closer to the second conductivity type layer than the cap layer;

the second region is closer to the cap layer than the second conductivity type layer; and

the second composition comprises a higher indium composition than the first composition.

27. The light emitting device of Claim 1 wherein the lower confinement layer comprises a composition graded from a first composition in a first region of the lower confinement layer to a second composition in a second region of the lower confinement layer, wherein:

the first region is closer to the first conductivity type layer than the spacer layer;

the second region is closer to the spacer layer than the first conductivity type layer; and

the second composition comprises a higher indium composition than the first composition.

28. The light emitting device of Claim 2 wherein the spacer layer and the cap layer have indium compositions greater than the barrier layer.

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Semiconductor light-emitting devices (LEDs) are among the most efficient light sources currently available. Materials systems currently of interest in the manufacture of high-brightness LEDs capable of operation across the visible spectrum include Group III-V semiconductors, particularly binary, ternary, and quaternary alloys of gallium, aluminum, indium, and nitrogen, also referred to as III-nitride materials. Typically, III-nitride light emitting devices are fabricated by epitaxially growing a stack of semiconductor layers of different compositions and dopant concentrations on a sapphire, silicon carbide, or III-nitride substrate by metal-organic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE), or other epitaxial techniques. The stack often includes one or more n-type layers doped with, for example, Si, formed over the substrate, a light emitting or active region

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formed over the n-type layer or layers, and one or more p-type layers doped with, for example, Mg, formed over the active region. (Specification, paragraph [0001])

The active region is often a single quantum well layer, or multiple quantum well layers separated by and sandwiched between layers of semiconductor materials with larger bandgap energies than the quantum well layers. The larger bandgap energy layers that separate the quantum well layers are often referred to as barrier layers. The larger bandgap energy layers between which the active region is located are often referred to as cladding or confinement layers. Other layers may be located between the confinement layers and the active region. The barrier and confinement layers provide barriers to the diffusion of charge carriers away from the active region. (Specification, paragraph [0002])

One aspect of the invention provides a semiconductor light emitting device. (Claim 1, Figs. 3 and 4, Specification paragraphs [0015] through [0027]) The device includes a substrate; a first conductivity type layer overlying the substrate; and an $In_xGa_{1-x}N$ lower confinement layer overlying the first conductivity type layer, wherein $0 \leq x \leq 0.15$; and a spacer layer overlying the lower confinement layer. The device also includes an active region overlying the spacer layer, the active region including a quantum well layer and a barrier layer comprising indium. Over the active region are a cap layer overlying the active region; an $In_xGa_{1-x}N$ upper confinement layer overlying and adjacent to the cap layer, wherein $0 \leq x \leq 0.15$; and a second conductivity type layer overlying the upper confinement layer. The spacer layer and the cap layer have larger band gaps than the quantum well layer. The upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer. One of the spacer layer and the cap layer comprises indium.

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Claim 1 recites:

> A light emitting device comprising:
> a substrate;
> a first conductivity type layer overlying the substrate;
> a lower confinement layer overlying the first conductivity type layer, the lower confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$;
> a spacer layer overlying the lower confinement layer;
> an active region overlying the spacer layer, the active region comprising:
> a quantum well layer; and
> a barrier layer comprising indium;
> a cap layer overlying the active region;
> an upper confinement layer overlying and adjacent to the cap layer, the upper confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$; and
> a second conductivity type layer overlying the upper confinement layer;
> wherein:
> the spacer layer and the cap layer have larger band gaps than the quantum well layer;
> the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer; and
> one of the spacer layer and the cap layer comprises indium.

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The Examiner cites Figs. 5, 6, and 7 of Sasanuma as teaching "a laser diode with a substrate 1, a first type layer 3, an InGaN layer 14, an AlGaN layer 15, an[] InGaN MQW

layer 16, an AlGaN layer 17, an InGaN layer 18, a GaN layer 8 and a second [p-]type layer 9." See July 22, 2003 Final Office Action, page 2. In the response to arguments section on page 6 of the same office action, the Examiner states "The layers of Sas[a]numa et al. were recited in the order shown in the claims and layer 15 and 17 correspond to the spacer and cap layers of the claims. Thus all the claimed layers are shown."

The Examiner has not specified which of Sasanuma's layers correspond to which of the layers in claim 1 other than that Sasanuma's layers 15 and 17 correspond to the spacer layer and the cap layer. Applicants assume that the Examiner intends for the layers of Sasanuma to correspond to claim 1 as follows:

Claim 1	Sasanuma
Substrate	Layer 1
First conductivity type layer	Layer 3
Lower confinement layer	Layer 14
Spacer layer	Layer 15
Active region	Layer 16
Cap layer	Layer 17
Upper confinement layer	Layer 18
Second conductivity type layer	Layer 8 or 9

Sverdlov is cited as teaching that Sasanuma's AlGaN layers 15 and 17 may be replaced with GaN layers. The Examiner states: "Sasanuma et al. show layers 15 and 17 as AlGaN and Sverdlov shows that AlGaN can be avoided by using GaN instead (see abstract) to improve the device as shown in the abstract. It would have been obvious to use the GaN as shown by Sverdlov to gain the advantage shown." See July 22, 2003 Final Office Action, page 2.

Applicants respectfully submit that the Examiner's combination of Sverdlov and Sasanuma does not teach that "the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer" as recited in claim 1. As recited above, the Examiner cites Sasanuma's AlGaN layers 15 and 17 of Fig. 6 as being the spacer and cap layer. Fig. 5 of Sasanuma clearly shows that AlGaN layers 15 and 17 have

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larger band gaps than InGaN layers 14 and 18, which Applicants assume the Examiner intends to be the upper and lower confinement layers of claim 1.

In addition, even if Sverdlov's GaN layers were substituted for Sasanuma's AlGaN layers 15 and 17 in Sasanuma's device as proposed by the Examiner, layers 15 and 17 *still* would not meet claim 1's requirement that "the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer", since InGaN layers 14 and 18, which Applicants assume the Examiner intends to be the upper and lower confinement layers of claim 1, contain indium. It is well known in the art that InGaN has a smaller band gap than GaN, and the band gap of InGaN decreases as the amount of indium increases.

Further, the Examiner's combination of Sasanuma and Sverdlov does not teach "one of the spacer layer and the cap layer comprises indium" as recited in claim 1. The layers of Sasanuma cited by the Examiner as the spacer layer and cap layer are AlGaN, and the Examiner cites Sverdlov as teaching that GaN can be substituted for AlGaN. If the spacer layer and cap layer are AlGaN or GaN, neither the spacer layer nor the cap layer comprises indium as recited in claim 1.

Since the Examiner's combination of Sasanuma and Sverdlov does not teach all the elements of claim 1, Applicants respectfully request that the Examiner's rejection is unfounded. Claims 2-17 and 19-28 depend from claim 1 and are therefore not obvious over Sasanuma and Sverdlov for at least the same reasons as claim 1.

Claims 2-5, 8, 10, 12, 15, 19, 21, and 24-28 are rejected over Sasanuma and Sverdlov in view of various other references. Each of the other references is directed to a limitation present in the dependent claims, and as such these references add nothing to the deficiencies of Sasanuma and Sverdlov with respect to claim 1, argued above.

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IX. CONCLUSION

For the above reasons, Applicants respectfully submit that the rejection of pending claims 1-17 and 19-28 is unfounded. Accordingly, Applicants request that the rejection be reversed.

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R Leiterman 5/17/04
Signature Date

Respectfully submitted,

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APPENDIX

1. A light emitting device comprising:

a substrate;

a first conductivity type layer overlying the substrate;

a lower confinement layer overlying the first conductivity type layer, the lower confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$;

a spacer layer overlying the lower confinement layer;

an active region overlying the spacer layer, the active region comprising:

a quantum well layer; and

a barrier layer comprising indium;

a cap layer overlying the active region;

an upper confinement layer overlying and adjacent to the cap layer, the upper confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$; and

a second conductivity type layer overlying the upper confinement layer;

wherein:

the spacer layer and the cap layer have larger band gaps than the quantum well layer;

the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer; and

one of the spacer layer and the cap layer comprises indium.

2. The light emitting device of Claim 1 wherein the spacer layer comprises indium; and

the barrier layer comprises InGaN with an indium composition between about 1% and about 15%.

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3. The light emitting device of Claim 2 wherein the barrier layer is InGaN having an indium composition between about 1% and about 5%.

4. The light emitting device of Claim 2 wherein the barrier layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{19} cm^{-3}.

5. The light emitting device of Claim 2 wherein:

the barrier layer has a thickness between about 20 angstroms and about 250 angstroms;

the quantum well layer has an indium composition between about 4% and about 25%; and

the quantum well layer has a thickness between about 10 angstroms and about 60 angstroms.

6. The light emitting device of Claim 1 wherein the barrier layer, the spacer layer, and the cap layer each have an indium composition less than an indium composition of the quantum well layer.

7. The light emitting device of Claim 1 wherein the lower confinement layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.02$.

8. The light emitting device of Claim 1 wherein the lower confinement layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{22} cm^{-3}.

9. The light emitting device of Claim 1 wherein the lower confinement layer has a thickness between about 50 and about 20,000 angstroms.

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10. The light emitting device of Claim 2 wherein:

the lower confinement layer has a first indium composition;

the spacer layer has a second indium composition;

the quantum well layer has a third indium composition;

the third indium composition is greater than the second indium composition; and

the second indium composition is greater than or equal to the first indium composition.

11. The light emitting device of Claim 1 wherein the upper confinement layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.02$.

12. The light emitting device of Claim 1 wherein the upper confinement layer is doped with a dopant of second conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{22} cm^{-3}.

13. The light emitting device of Claim 12 wherein the dopant comprises Mg.

14. The light emitting device of Claim 1 wherein the upper confinement layer has a thickness between about 50 and about 20,000 angstroms.

15. The light emitting device of Claim 2 wherein:

the upper confinement layer has a first indium composition;

the cap layer has a second indium composition;

the quantum well layer has a third indium composition;

the third indium composition is greater than the second indium composition; and

the second indium composition is greater than or equal to the first indium composition.

16. The light emitting device of Claim 1 wherein the cap layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$.

17. The light emitting device of Claim 1 wherein the spacer layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$.

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19. The light emitting device of Claim 1 wherein at least one of the cap layer, the upper confinement layer, the lower confinement layer, and the spacer layer comprises a graded composition of indium.

20. The light emitting device of Claim 1 wherein the cap layer is doped with a dopant of second conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{21} cm^{-3}.

21. The light emitting device of Claim 1 wherein the spacer layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{21} cm^{-3}.

22. The light emitting device of Claim 1 wherein the first conductivity type layer and the second conductivity type layer have larger band gaps than the lower confinement layer and the upper confinement layer.

23. The light emitting device of Claim 1 wherein the spacer layer and the cap layer have larger band gaps than the barrier layer.

24. The light emitting device of Claim 1 wherein the spacer layer comprises a composition graded from a first composition in a first region of the spacer layer to a second composition in a second region of the spacer layer, wherein:

the first region is closer to the lower confinement layer than the active region;

the second region is closer to the active region than the lower confinement layer; and

the second composition comprises a higher indium composition than the first composition.

25. The light emitting device of Claim 1 wherein the cap layer comprises a composition graded from a first composition in a first region of the cap layer to a second composition in a second region of the cap layer, wherein:

the first region is closer to the upper confinement layer than the active region;

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the second region is closer to the active region than the upper confinement layer; and

the second composition comprises a higher indium composition than the first composition.

26. The light emitting device of Claim 1 wherein the upper confinement layer comprises a composition graded from a first composition in a first region of the upper confinement layer to a second composition in a second region of the upper layer, wherein:

the first region is closer to the second conductivity type layer than the cap layer;

the second region is closer to the cap layer than the second conductivity type layer; and

the second composition comprises a higher indium composition than the first composition.

27. The light emitting device of Claim 1 wherein the lower confinement layer comprises a composition graded from a first composition in a first region of the lower confinement layer to a second composition in a second region of the lower confinement layer, wherein:

the first region is closer to the first conductivity type layer than the spacer layer;

the second region is closer to the spacer layer than the first conductivity type layer; and

the second composition comprises a higher indium composition than the first composition.

28. The light emitting device of Claim 2 wherein the spacer layer and the cap layer have indium compositions greater than the barrier layer.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Yu-Chen Shen; Mira S. Misra		
Assignee:	Lumileds Lighting U.S. LLC		
Title:	Indium Gallium Nitride Separate Confinement Heterostructure Light Emitting Devices		
Serial No.:	10/033,349	Filing Date:	November 2, 2001
Examiner:	Douglas A. Wille	Group Art Unit:	2814
Docket No.:	M-11972 US		

San Jose, California
May 17, 2004

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Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

APPEAL BRIEF UNDER 37 CFR § 1.191

Dear Sir:

Applicants submit this Appeal Brief pursuant to the Notice of Appeal filed in this case on December 15, 2003. The Commissioner is hereby authorized to deduct from Deposit Account No. 502226 the amount $330.00 specified in 37 CFR 1.17(c) for this Appeal Brief. Applicants respectfully petition for a 3-month extension of time, such extension allowing the undersigned until May 15, 2004 to file the Appeal Brief. The Commissioner is hereby authorized to deduct the amount of $950.00 from Deposit Account No. 502226 for the extension of time. The Commissioner is also authorized to deduct any other amounts required for this appeal brief and to credit any amounts overpaid to Deposit Account No. 502226. This paper is submitted in triplicate.

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I. REAL PARTY IN INTEREST

The real partying interest is the assignee, Lumileds Lighting U.S. LLC, as named in the caption above.

II. RELATED APPEALS AND INTERFERENCES

Based on information and belief, there are no appeals or interferences that could directly affect or be directly affected by or have a bearing on the decision by the Board of Patent Appeals in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-17 and 19-28 are pending in the present application, all of which stand rejected. Claim 18 is canceled. Claims 1-17 and 19-28 are hereby appealed.

IV. STATUS OF AMENDMENTS

The Examiner issued the final action on July 22, 2003. Applicants did not file an after final amendment.

V. SUMMARY OF THE INVENTION

Semiconductor light-emitting devices (LEDs) are among the most efficient light sources currently available. Materials systems currently of interest in the manufacture of high-brightness LEDs capable of operation across the visible spectrum include Group III-V semiconductors, particularly binary, ternary, and quaternary alloys of gallium, aluminum, indium, and nitrogen, also referred to as III-nitride materials. Typically, III-nitride light emitting devices are fabricated by epitaxially growing a stack of semiconductor layers of different compositions and dopant concentrations on a sapphire, silicon carbide, or III-nitride substrate by metal-organic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE), or other epitaxial techniques. The stack often includes one or more n-type layers doped with, for example, Si, formed over the substrate, a light emitting or active region

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formed over the n-type layer or layers, and one or more p-type layers doped with, for example, Mg, formed over the active region. (Specification, paragraph [0001])

The active region is often a single quantum well layer, or multiple quantum well layers separated by and sandwiched between layers of semiconductor materials with larger bandgap energies than the quantum well layers. The larger bandgap energy layers that separate the quantum well layers are often referred to as barrier layers. The larger bandgap energy layers between which the active region is located are often referred to as cladding or confinement layers. Other layers may be located between the confinement layers and the active region. The barrier and confinement layers provide barriers to the diffusion of charge carriers away from the active region. (Specification, paragraph [0002])

One aspect of the invention provides a semiconductor light emitting device. (Claim 1, Figs. 3 and 4, Specification paragraphs [0015] through [0027]) The device includes a substrate; a first conductivity type layer overlying the substrate; and an $In_xGa_{1-x}N$ lower confinement layer overlying the first conductivity type layer, wherein $0 \leq x \leq 0.15$; and a spacer layer overlying the lower confinement layer. The device also includes an active region overlying the spacer layer, the active region including a quantum well layer and a barrier layer comprising indium. Over the active region are a cap layer overlying the active region; an $In_xGa_{1-x}N$ upper confinement layer overlying and adjacent to the cap layer, wherein $0 \leq x \leq 0.15$; and a second conductivity type layer overlying the upper confinement layer. The spacer layer and the cap layer have larger band gaps than the quantum well layer. The upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer. One of the spacer layer and the cap layer comprises indium.

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VI. ISSUES

Whether claims 1-17 and 19-28 are unpatentable under 35 U.S.C. § 103(a) as being obvious over Sasanuma et al. JP 11243251 in view of Sverdlov, U.S. Patent No. 6,455,337.

VII. GROUPING OF THE CLAIMS

Claims 1-17 and 19-28 stand or fall together.

VIII. ARGUMENTS

Claims 1, 6, 7, 9, 11, 13, 14, 16, 17, 20, 22 and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sasanuma et al. JP 11243251 (hereinafter "Sasanuma") in view of Sverdlov, U.S. Patent No. 6,455,337.

Claim 1 recites:

> A light emitting device comprising:
> a substrate;
> a first conductivity type layer overlying the substrate;
> a lower confinement layer overlying the first conductivity type layer, the lower confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$;
> a spacer layer overlying the lower confinement layer;
> an active region overlying the spacer layer, the active region comprising:
> a quantum well layer; and
> a barrier layer comprising indium;
> a cap layer overlying the active region;
> an upper confinement layer overlying and adjacent to the cap layer, the upper confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$; and
> a second conductivity type layer overlying the upper confinement layer;
> wherein:
> the spacer layer and the cap layer have larger band gaps than the quantum well layer;
> the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer; and
> one of the spacer layer and the cap layer comprises indium.

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The Examiner cites Figs. 5, 6, and 7 of Sasanuma as teaching "a laser diode with a substrate 1, a first type layer 3, an InGaN layer 14, an AlGaN layer 15, an[] InGaN MQW

layer 16, an AlGaN layer 17, an InGaN layer 18, a GaN layer 8 and a second [p-]type layer 9." See July 22, 2003 Final Office Action, page 2. In the response to arguments section on page 6 of the same office action, the Examiner states "The layers of Sas[a]numa et al. were recited in the order shown in the claims and layer 15 and 17 correspond to the spacer and cap layers of the claims. Thus all the claimed layers are shown."

The Examiner has not specified which of Sasanuma's layers correspond to which of the layers in claim 1 other than that Sasanuma's layers 15 and 17 correspond to the spacer layer and the cap layer. Applicants assume that the Examiner intends for the layers of Sasanuma to correspond to claim 1 as follows:

Claim 1	Sasanuma
Substrate	Layer 1
First conductivity type layer	Layer 3
Lower confinement layer	Layer 14
Spacer layer	Layer 15
Active region	Layer 16
Cap layer	Layer 17
Upper confinement layer	Layer 18
Second conductivity type layer	Layer 8 or 9

Sverdlov is cited as teaching that Sasanuma's AlGaN layers 15 and 17 may be replaced with GaN layers. The Examiner states: "Sasanuma et al. show layers 15 and 17 as AlGaN and Sverdlov shows that AlGaN can be avoided by using GaN instead (see abstract) to improve the device as shown in the abstract. It would have been obvious to use the GaN as shown by Sverdlov to gain the advantage shown." See July 22, 2003 Final Office Action, page 2.

Applicants respectfully submit that the Examiner's combination of Sverdlov and Sasanuma does not teach that "the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer" as recited in claim 1. As recited above, the Examiner cites Sasanuma's AlGaN layers 15 and 17 of Fig. 6 as being the spacer and cap layer. Fig. 5 of Sasanuma clearly shows that AlGaN layers 15 and 17 have

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larger band gaps than InGaN layers 14 and 18, which Applicants assume the Examiner intends to be the upper and lower confinement layers of claim 1.

In addition, even if Sverdlov's GaN layers were substituted for Sasanuma's AlGaN layers 15 and 17 in Sasanuma's device as proposed by the Examiner, layers 15 and 17 *still* would not meet claim 1's requirement that "the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer", since InGaN layers 14 and 18, which Applicants assume the Examiner intends to be the upper and lower confinement layers of claim 1, contain indium. It is well known in the art that InGaN has a smaller band gap than GaN, and the band gap of InGaN decreases as the amount of indium increases.

Further, the Examiner's combination of Sasanuma and Sverdlov does not teach "one of the spacer layer and the cap layer comprises indium" as recited in claim 1. The layers of Sasanuma cited by the Examiner as the spacer layer and cap layer are AlGaN, and the Examiner cites Sverdlov as teaching that GaN can be substituted for AlGaN. If the spacer layer and cap layer are AlGaN or GaN, neither the spacer layer nor the cap layer comprises indium as recited in claim 1.

Since the Examiner's combination of Sasanuma and Sverdlov does not teach all the elements of claim 1, Applicants respectfully request that the Examiner's rejection is unfounded. Claims 2-17 and 19-28 depend from claim 1 and are therefore not obvious over Sasanuma and Sverdlov for at least the same reasons as claim 1.

Claims 2-5, 8, 10, 12, 15, 19, 21, and 24-28 are rejected over Sasanuma and Sverdlov in view of various other references. Each of the other references is directed to a limitation present in the dependent claims, and as such these references add nothing to the deficiencies of Sasanuma and Sverdlov with respect to claim 1, argued above.

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IX. CONCLUSION

For the above reasons, Applicants respectfully submit that the rejection of pending claims 1-17 and 19-28 is unfounded. Accordingly, Applicants request that the rejection be reversed.

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R Leiterman 5/17/04

Signature Date

Respectfully submitted,

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APPENDIX

1. A light emitting device comprising:

a substrate;

a first conductivity type layer overlying the substrate;

a lower confinement layer overlying the first conductivity type layer, the lower confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$;

a spacer layer overlying the lower confinement layer;

an active region overlying the spacer layer, the active region comprising:

a quantum well layer; and

a barrier layer comprising indium;

a cap layer overlying the active region;

an upper confinement layer overlying and adjacent to the cap layer, the upper confinement layer comprising $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$; and

a second conductivity type layer overlying the upper confinement layer;

wherein:

the spacer layer and the cap layer have larger band gaps than the quantum well layer;

the upper confinement layer and the lower confinement layer have larger band gaps than the spacer layer and the cap layer; and

one of the spacer layer and the cap layer comprises indium.

2. The light emitting device of Claim 1 wherein the spacer layer comprises indium; and

the barrier layer comprises InGaN with an indium composition between about 1% and about 15%.

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3. The light emitting device of Claim 2 wherein the barrier layer is InGaN having an indium composition between about 1% and about 5%.

4. The light emitting device of Claim 2 wherein the barrier layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{19} cm^{-3}.

5. The light emitting device of Claim 2 wherein:

the barrier layer has a thickness between about 20 angstroms and about 250 angstroms;

the quantum well layer has an indium composition between about 4% and about 25%; and

the quantum well layer has a thickness between about 10 angstroms and about 60 angstroms.

6. The light emitting device of Claim 1 wherein the barrier layer, the spacer layer, and the cap layer each have an indium composition less than an indium composition of the quantum well layer.

7. The light emitting device of Claim 1 wherein the lower confinement layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.02$.

8. The light emitting device of Claim 1 wherein the lower confinement layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{22} cm^{-3}.

9. The light emitting device of Claim 1 wherein the lower confinement layer has a thickness between about 50 and about 20,000 angstroms.

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10. The light emitting device of Claim 2 wherein:

the lower confinement layer has a first indium composition;

the spacer layer has a second indium composition;

the quantum well layer has a third indium composition;

the third indium composition is greater than the second indium composition; and

the second indium composition is greater than or equal to the first indium composition.

11. The light emitting device of Claim 1 wherein the upper confinement layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.02$.

12. The light emitting device of Claim 1 wherein the upper confinement layer is doped with a dopant of second conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{22} cm^{-3}.

13. The light emitting device of Claim 12 wherein the dopant comprises Mg.

14. The light emitting device of Claim 1 wherein the upper confinement layer has a thickness between about 50 and about 20,000 angstroms.

15. The light emitting device of Claim 2 wherein:

the upper confinement layer has a first indium composition;

the cap layer has a second indium composition;

the quantum well layer has a third indium composition;

the third indium composition is greater than the second indium composition; and

the second indium composition is greater than or equal to the first indium composition.

16. The light emitting device of Claim 1 wherein the cap layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$.

17. The light emitting device of Claim 1 wherein the spacer layer comprises $In_xGa_{1-x}N$, wherein $0 \leq x \leq 0.15$.

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19. The light emitting device of Claim 1 wherein at least one of the cap layer, the upper confinement layer, the lower confinement layer, and the spacer layer comprises a graded composition of indium.

20. The light emitting device of Claim 1 wherein the cap layer is doped with a dopant of second conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{21} cm^{-3}.

21. The light emitting device of Claim 1 wherein the spacer layer is doped with a dopant of first conductivity type to a concentration between about 10^{15} cm^{-3} and about 10^{21} cm^{-3}.

22. The light emitting device of Claim 1 wherein the first conductivity type layer and the second conductivity type layer have larger band gaps than the lower confinement layer and the upper confinement layer.

23. The light emitting device of Claim 1 wherein the spacer layer and the cap layer have larger band gaps than the barrier layer.

24. The light emitting device of Claim 1 wherein the spacer layer comprises a composition graded from a first composition in a first region of the spacer layer to a second composition in a second region of the spacer layer, wherein:

the first region is closer to the lower confinement layer than the active region;

the second region is closer to the active region than the lower confinement layer; and

the second composition comprises a higher indium composition than the first composition.

25. The light emitting device of Claim 1 wherein the cap layer comprises a composition graded from a first composition in a first region of the cap layer to a second composition in a second region of the cap layer, wherein:

the first region is closer to the upper confinement layer than the active region;

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the second region is closer to the active region than the upper confinement layer; and

the second composition comprises a higher indium composition than the first composition.

26. The light emitting device of Claim 1 wherein the upper confinement layer comprises a composition graded from a first composition in a first region of the upper confinement layer to a second composition in a second region of the upper layer, wherein:

the first region is closer to the second conductivity type layer than the cap layer;

the second region is closer to the cap layer than the second conductivity type layer; and

the second composition comprises a higher indium composition than the first composition.

27. The light emitting device of Claim 1 wherein the lower confinement layer comprises a composition graded from a first composition in a first region of the lower confinement layer to a second composition in a second region of the lower confinement layer, wherein:

the first region is closer to the first conductivity type layer than the spacer layer;

the second region is closer to the spacer layer than the first conductivity type layer; and

the second composition comprises a higher indium composition than the first composition.

28. The light emitting device of Claim 2 wherein the spacer layer and the cap layer have indium compositions greater than the barrier layer.

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